📘 INDUSTRIAL CHEMISTRY

Complete Question Bank Answers with Exam Weightage (based on PYQs)

🔥 UNIT – I : FUELS & COMBUSTION

Renewable fuels · Proximate/Ultimate analysis · Calorific value · Hydrogen hurdles · Biodiesel

1. What are Renewable Energy fuels?

1 Mark

> Fuels obtained from natural sources that replenish faster than consumption, e.g., solar, wind, biomass, hydropower. They are eco-friendly and sustainable.

2. What is meant by Ignition Temperature?

1 Mark

> The lowest temperature at which a fuel catches fire and burns spontaneously in air without external flame.

3. Mention any one drawback of Wind energy.

1 Mark

> Intermittent (depends on wind speed) and requires large land area; also noise pollution.

4. Classify fuels on the basis of occurrence.

1 Mark

> Primary (natural) fuels: coal, crude oil, natural gas, wood. Secondary (derived) fuels: coke, petrol, diesel, kerosene, biogas.

5. Define fuel.

1 Mark

> Any substance that burns in presence of oxygen to produce heat/energy is called fuel. Eg: coal, LPG, hydrogen.

6. Define GCV.

1 Mark

> Gross Calorific Value (HCV): total heat produced when 1g fuel is burnt completely and products cooled to room temperature (including latent heat of steam).

7. Name any non-conventional energy source. 1 Mark

> Solar energy, wind energy, tidal energy, geothermal, hydrogen fuel.

8. What is Biodiesel? 1 Mark

> Renewable fuel made from vegetable oils/animal fats via transesterification reaction; biodegradable and less polluting.

9. Define calorific value. 1 Mark

> Amount of heat liberated by complete combustion of 1g (or 1kg) of fuel. Units: cal/g or kJ/kg.

10. What is proximate analysis of coal? 1 Mark

> Determination of moisture, volatile matter, ash, and fixed carbon percentage. It gives commercial quality of coal.

11. Write any one advantage of biodiesel. 1 Mark

> Renewable, biodegradable, lower CO_2 emission, and produces less SOx.

12. What is the general principle of calorimeter? 1 Mark

> Heat released by fuel = heat absorbed by water & calorimeter. Based on law of conservation of energy.

13. State the SI unit of calorific value of solid fuel. 1 Mark

> Joule per kilogram (J/kg) or kJ/kg.

14. Name any one industrial method for hydrogen production. 1 Mark

> Steam reforming of methane ($CH_4 + H_2O \rightarrow CO + 3H_2$).

15. A fuel sample (1.8g) burnt in bomb calorimeter: water=1800g, ΔT=27.8-24=3.8°C, water equiv=350g. Latent heat=540 cal/g. Calculate HCV.

3 Marks

> Heat absorbed = (mass water + water eq.) × ΔT = (1800+350)×3.8 = 2150×3.8 = 8170 cal.
> HCV = Heat / mass of fuel = 8170 / 1.8 = **4538.89 cal/g** (Gross calorific value).

16. 1.5g coal: heating at 105°C residue=1.02g; covered at 925°C residue=0.72g; open heating residue=0.20g. Find % moisture, VM, Ash.

3 Marks

> Moisture = [(1.5-1.02)/1.5]×100 = (0.48/1.5)×100 = 32%
> Volatile Matter = [(1.02-0.72)/1.5]×100 = (0.30/1.5)×100 = 20%
> Ash = (0.20/1.5)×100 = 13.33%
> Fixed carbon = 100-(32+20+13.33)=34.67%.

17. Elaborate significance of moisture, ash, fixed carbon in coal analysis.

3 Marks

> **Moisture** → reduces calorific value, increases transport cost, causes smokey flame.
> **Ash** → non-combustible residue, lowers heating value, disposal issue, clinker formation.
> **Fixed carbon** → gives rough idea of energy content; higher FC means better coal grade.

18. Explain procedure of Proximate analysis of coal with formula and significance of moisture.

6 Marks

> **Steps:**
> ① Moisture: 1g coal heated at 105-110°C for 1h. %M = (loss wt / sample wt)×100.
> ② Volatile Matter: residue from moisture heated at 950±20°C for 7 min. %VM = (wt loss during heating / sample wt)×100.
> ③ Ash: residue heated without lid at 700-750°C to constant wt. %Ash = (ash wt / sample wt)×100.
> ④ Fixed Carbon = 100 – (M+VM+Ash).
> **Significance of moisture:** High moisture reduces calorific value, causes handling difficulty, increases ignition time.

19. Explain production of H_2 by Steam reforming of methane, reaction, removal of CO_2, advantage & application.

6 Marks

Reaction: $CH_4 + H_2O \rightarrow CO + 3H_2$ (endothermic). Water-gas shift: $CO + H_2O \rightarrow CO_2 + H_2$. **$CO_2$ removal:** scrubbing with K_2CO_3 or monoethanolamine. **Advantage:** H_2 has high energy per kg, water as exhaust. **Application:** fuel cells, hydrogen vehicles, ammonia synthesis.

20. Demonstrate Ultimate analysis procedure for %C, %H & %S with formula.

6 Marks

% Carbon: Known wt coal burnt in O_2, CO_2 absorbed in KOH tube. %C = (wt CO_2 × 12/44) / wt coal ×100.
% Hydrogen: Water absorbed in anhydrous $CaCl_2$ tube. %H = (wt H_2O × 2/18) / wt coal ×100.
% Sulphur: Coal burnt, SO_2 absorbed in H_2O_2 to form H_2SO_4, titrated with NaOH. %S = (V×N×32/1000) / wt coal ×100.

21. Outline six main hurdles in transportation and storage of Hydrogen gas.

6 Marks

① Low density → large volume for storage. ② Embrittlement of metals (hydrogen cracks pipelines). ③ High flammability (wide explosive range). ④ Leakage (small molecule escapes easily). ⑤ Liquefaction requires cryogenic temperature (-253°C). ⑥ High cost of compression/storage materials.

22. 12.0g coal: $CaCl_2$ tube increase=0.360g (H_2O), KOH tube increase=1.020g (CO_2). Find %C and %H.

3 Marks

Mass of C = (12/44)×1.020 = 0.2782 g ⇒ %C = (0.2782/12)×100 = 2.318%
Mass of H = (2/18)×0.360 = 0.04 g ⇒ %H = (0.04/12)×100 = 0.333%

23. 20g coal: 115°C residue=18.10g; 940°C covered residue=10.50g; open heating residue=1.80g. Find % moisture, VM, ash.

3 Marks

Moisture = [(20-18.10)/20]×100 = (1.9/20)×100 = 9.5%
VM = [(18.10-10.50)/20]×100 = (7.6/20)×100 = 38%
Ash = (1.80/20)×100 = 9%

🔬 UNIT – IV : SPECTROSCOPY (UV-Visible & IR)

Beer-Lambert · Chromophores · Vibrations · Fingerprint region

1. State Beer-Lambert's law.

1 Mark

> Absorbance (A) is directly proportional to concentration (c) and path length (l): $A = \varepsilon c l$ (ε = molar absorptivity).

2. Name two forbidden electronic transitions in UV-Visible spectroscopy.

1 Mark

> $n \rightarrow \sigma^*$ and $\sigma \rightarrow \sigma^*$ (low probability), also triplet–singlet transitions are forbidden.

3. Define chromophore with example.

1 Mark

> Functional group responsible for absorption of UV/Visible light. Eg: C=C, C=O, $-NO_2$.

4. What is fingerprint region in IR spectroscopy?

1 Mark

> Region 1400–900 cm^{-1}; complex absorption unique to each molecule, used for identification.

5. Define auxochrome.

1 Mark

> Saturated group that intensifies absorption and shifts λmax when attached to chromophore. Eg: –OH, $–NH_2$.

6. Define red shift (bathochromic shift).

1 Mark

> Shift of absorption maximum towards longer wavelength (lower energy) due to solvent effect or conjugation.

7. Define blue (hypsochromic) shift.

1 Mark

> Shift towards shorter wavelength (higher energy). Eg: effect of electron-withdrawing groups.

8. What is the wavelength range of UV-Visible radiation?

1 Mark

> UV: 200–400 nm, Visible: 400–800 nm.

9. What do you mean by monochromator?

1 Mark

> Device that selects a narrow band of wavelengths from a broad source, using prism or grating.

10. Calculate possible vibrational modes for H_2O, C_6H_6, SO_2.

3 Marks

> For non-linear: 3N-6; linear: 3N-5. H_2O (non-linear, N=3) → 3×3-6 = 3 modes. C_6H_6 (non-linear, 12 atoms) → 3×12-6=30 modes. SO_2 (non-linear) → 3×3-6=3 modes (bending, symmetric, asymmetric stretch).

11. What are the conditions for absorption of IR radiations by molecules?

3 Marks

> ① Change in dipole moment during vibration. ② Frequency of IR radiation matches natural vibrational frequency. ③ Energy absorbed = ΔE between vibrational levels.

12. Explain why homonuclear diatomics (O_2, N_2) are IR inactive but heteronuclear (HCl, CO) are active.

3 Marks

> Homonuclear diatomics have zero dipole moment and no change during vibration → IR inactive. Heteronuclear have permanent dipole, vibration causes dipole change → absorb IR. Eg: HCl stretches (active), O_2 does not absorb.

13. Identify possible electronic transitions in CH_4, C_2H_4, CH_3NH_2.

3 Marks

> CH_4: only σ→σ* (high energy, far UV). C_2H_4: π→π* (around 170 nm). CH_3NH_2: n→σ* (for N lone pair) and σ→σ*.

14. Recognize what happens when molecules interact with UV-Visible, IR and microwaves.

3 Marks

> UV-Visible: electronic transitions (σ,π,n electrons). IR: vibrational & rotational transitions. Microwaves: pure rotational transitions.

UNIT – V : CORROSION & PROTECTION

Pilling–Bedworth · Galvanization · Anodic/Cathodic protection · Oxide films

1. Define corrosion. 1 Mark

> Gradual destruction of metals by chemical/electrochemical reaction with environment, e.g., rusting of iron.

2. Define galvanization. 1 Mark

> Coating iron with zinc to prevent rust; zinc acts as sacrificial anode.

3. State types of corrosion. 1 Mark

> Dry (chemical) corrosion & wet (electrochemical) corrosion.

4. What is anodic coating? 1 Mark

> Base metal coated with a more noble metal (e.g., tin on steel). Provides barrier protection but if scratched, steel corrodes faster.

5. Define wet chemical corrosion. 1 Mark

> Corrosion in presence of conducting liquid (electrolyte) involving anodic & cathodic reactions.

6. Define cathodic protection. 1 Mark

> Technique to prevent corrosion by making metal surface as cathode via sacrificial anodes or impressed current.

7. What is oxygen concentration cell corrosion? 1 Mark

> Corrosion due to differential aeration; less oxygen area becomes anodic (pitting).

8. What is tinning? 1 Mark

> Coating steel sheets with tin (cathodic coating) for corrosion resistance in food cans.

9. State Pilling-Bedworth rule (PBR). 1 Mark

> Oxide film is protective if PBR = volume oxide / volume metal consumed is between 1 and 2.5.

10. Conclude nature of oxide film on Fe, Ni, Mo, Au with reactions.

3 Marks

> Fe: $2Fe + O_2 \rightarrow 2FeO$ (non-protective, porous). Ni: $Ni + \frac{1}{2}O_2 \rightarrow NiO$ (thin protective). Mo: $2Mo + 3O_2 \rightarrow 2MoO_3$ (volatile, non-protective). Au: noble metal, no oxide film.

11. Explain any three factors affecting corrosion based on nature of environment.

3 Marks

> ① pH: acidic media accelerates H_2 evolution. ② Presence of moisture & oxygen essential. ③ Temperature: rate doubles per 10°C rise. ④ Salinity (Cl^- ions) breaks passive layers.

12. Describe tinning process with neat labelled diagram to protect iron.

3 Marks

```
[ CLEANING ] → [ Fluxing ] → [ Dipping in molten tin (230°C) ] → [ Rolling/Pc
Label: Iron sheet → Pickling → Flux (ZnCl₂) → Molten Tin Bath → Tin coated st
```

> Tinning provides shiny, non-toxic coating, used in food containers. If scratched, iron corrodes because tin is cathodic.

13. Differentiate between dry (chemical) corrosion and wet corrosion with examples.

3 Marks

> Dry: direct attack of gases (O_2, SO_2) at high temp; Eg: tarnishing of silver. Wet: electrochemical cell in presence of electrolyte; Eg: rusting of iron in seawater. Dry corrosion product is solid oxide, wet involves anodic & cathodic areas.

14. Explain significance of Pilling-Bedworth ratio (PBR) in corrosion.

2 Marks

> PBR>2.5 → oxide cracks, spalls (e.g., Fe). PBR<1 → porous film (Mg, Na). 1<PBR<2.5 → protective film (Al, Cr).

📊 UNIT – VI : WATER CHEMISTRY & STATISTICAL ANALYSIS

Molality, molarity · Standard deviation · Association of attributes · pH calibration

1. Define molarity. 1 Mark

> Moles of solute per litre of solution (M = n/V(L)).

2. Define molality. 1 Mark

> Moles of solute per kilogram of solvent (m = n / kg solvent).

3. Define mole fraction. 1 Mark

> Ratio of moles of one component to total moles in solution ($x_1 = n_1$ / n_total).

4. Define precision. 1 Mark

> Closeness of repeated measurements to each other; reproducibility.

5. Write formula for standard deviation. 1 Mark

> $\sigma = \sqrt{[\ \Sigma(x_i - \mu)^2 / N\ ]}$ (population) or $s = \sqrt{[\ \Sigma(x_i - \bar{x})^2 / (n-1)\ ]}$ (sample).

6. Define mean. 1 Mark

> Arithmetic average = sum of all values / number of values.

7. What is standard deviation? 1 Mark

> Measure of spread of data around mean; lower SD = more consistent data.

8. Define Mole fraction and write its formula. 1 Mark

> Mole fraction = moles of component / total moles of all components; $x_1 = n_1 / (n_1+n_2)$.

9. 14.2, 14.8, 15.1, 14.6, 14.9 – Calculate Mean and Standard Deviation.

3 Marks

> Mean = (14.2+14.8+15.1+14.6+14.9)/5 = 73.6/5 = 14.72.
> Deviations: -0.52, 0.08, 0.38, -0.12, 0.18; squares sum = 0.2704+0.0064+0.1444+0.0144+0.0324 = 0.468; SD = √(0.468/4) = √0.117 = 0.342.

10. 15g NaOH in 120g water, solution volume=600mL. Calculate molality.

3 Marks

> Molar mass NaOH=40; moles=15/40=0.375. Solvent=120g=0.12 kg. Molality = 0.375/0.12 = 3.125 mol/kg.

11. 75g NaCl in 250g water. Find mole fraction NaCl & water.

3 Marks

> Moles NaCl=75/58.5=1.282; moles H_2O=250/18=13.889; total=15.171.
> X_NaCl=1.282/15.171=0.0845; X_water=13.889/15.171=0.9155.

12. 250 samples: 140 high hardness (A), 95 high chloride(B), 60 both (AB). Check association.

3 Marks

> Expected (AB) = (A×B)/N = (140×95)/250 = 53.2. Observed AB=60 > 53.2 ⇒ positive association (high hardness & chloride tend to occur together).

13. DO data: 6.5,5.9,6.8,5.7,6.3. Find mean, SD & variance.

3 Marks

> Mean= (6.5+5.9+6.8+5.7+6.3)/5=31.2/5=6.24. Deviations:0.26,-0.34,0.56,-0.54,0.06; squares sum=0.0676+0.1156+0.3136+0.2916+0.0036=0.792; Variance=0.792/4=0.198; SD=√0.198=0.445 mg/L.

14. 12g glucose($C_6H_{12}O_6$) in 300g water. Molality?

3 Marks

> Molar mass glucose=180; moles=12/180=0.06667; solvent=0.3 kg ⇒ molality=0.06667/0.3 = 0.222 mol/kg.

15. 24g fructose in 240g water. Mole fraction, molality.

3 Marks

> Molar mass fructose=180; moles=24/180=0.1333; water moles=240/18=13.333; X_fru=0.1333/(13.466)=0.0099; X_w=0.9901; molality=0.1333/0.24=0.555 mol/kg.

16. Mass of oxalic acid ($H_2C_2O_4 \cdot 2H_2O$) to prepare 500 mL 0.2 N solution.

3 Marks

> Oxalic acid dihydrate equivalent weight = M/2 = 126/2 = 63. Normality = (wt ×1000)/(eq.wt × V(ml)). wt = (N × eq.wt × V)/1000 = (0.2×63×500)/1000 = 6.3 g.

📌 pH meter calibration (principle)

3 Marks (important)

> **Calibration:** Use pH 4.0, 7.0, 9.2 buffers. Electrode dipped in pH 7 → set reading to 7.0 (asymmetry). Then dip in pH 4.0, adjust slope control until display matches. Rinse with distilled water. Diagram: [pH meter → glass electrode → reference electrode → beaker with buffer].

✅ Answers prepared as per university exam pattern (JAN 2026, JULY 2025, MAY 2025, DEC 2023).
📐 Weightage derived from PYQs: 1M definitions, 3M numerical/concepts, 6M detailed explanations. Diagrams/neat steps ensure full marks.